CLAIMS

What is claimed is:

1. A micromachined optical scanner, comprising:

a base;

a central body coupled to the base in a manner that permits the central body to rotate relative to the base about an axis of rotation, the central body having a first portion of its mass offset from the axis of rotation in a first direction and a second portion of its mass offset from the axis of rotation in a second direction different from the first direction; and

a movable mass carried by the central body and coupled to the central body in a manner that permits the movable mass to move relative to the axis of rotation along a path having a component in the first direction, the scanner having a resonant frequency that is a function of the first portion of the central body mass and a position of the movable mass along the path.

2. The micromachined optical scanner of claim 1 futher comprising:

a flexible arm interposed between the movable mass and the central body, the flexible arm defining the path; and

an actuator coupled to one of the flexible arm and the movable mass, the actuator being responsive to an electrical signal to move the movable mass along the defined path.

3. The micromachined optical scanner of claim 2 wherein the input signal is an electrical signal, further including an electrical terminal coupled to the actuator.

4. The micromachined optical scanner of claim 2 wherein the actuator includes:

a first plate positioned on one of the flexible arm and the movable mass; and

a second plate positioned to produce an electrostatic force between the first and second plates when a voltage is applied between the first and second plates.

5. A microelectromechanical resonant device, comprising:

a base;

a movable body coupled to the base for resonant motion relative to the base about a pivot axis;

a flexible member extending from the movable body, the flexible member including a center of mass offset from the pivot axis by an offset distance, the flexible member being configured to flex in response to an applied force to vary the offset distance; and

an actuator positioned to apply the force to the flexible member.

6. The microelectromechanical resonant device of claim 5 wherein the actuator includes:

a first electrode carried by the flexible member; and

a second electrode positioned to produce an electrical field extending between the first and second electrodes.

7. The microelectromechanical resonant device of claim 5 wherein the movable body and flexible member form an integral body.

8. The microelectromechanical resonant device of claim 5 wherein the base and movable body are both formed from a semiconductor material.

9. The microelectromechanical resonant device of claim 5 wherein the movable body includes a polysilicon material.

10. The microelectromechanical resonant device of claim 5 further comprising a frame interposed between the base and the movable body, the frame being coupled to the base and configured for movement about a second axis substantially orthogonal to the pivot axis.

11. An optical scanner comprising:

an oscillatory body;

a body support coupled to the oscillatory body and configured to permit the oscillatory body to move about a pivot axis;

a movable mass carried by the oscillatory body and offset from the pivot axis, the movable mass being responsive to an electrical signal to move radially relative to the pivot axis;

a sensor oriented to detect motion of the oscillatory body, the sensor being operative to produce a sense signal indicative of the detected motion; and

an electronic control circuit having an input terminal coupled to the sensor and an output terminal coupled to the movable mass, electronic control circuit being responsive to the sense signal to produce the electrical signal.

12. The optical scanner of claim 11 wherein the electronic control circuit includes an error detection circuit having a first input terminal for receiving a reference signal and a second input terminal coupled to receive the sense signal, the error detection circuit being operative to produce the electrical signal as a function of a difference between the sense signal and the reference signal.

13. The optical scanner of claim 11 wherein the oscillatory body and the movable mass are integrally formed from a common material.

14. The optical scanner of claim 13 wherein the common material is a semiconductor.

15. The optical scanner of claim 11 wherein the movable mass includes a first electrode and the oscillatory body includes a second electrode, the first and second electrodes being oriented to produce an electric field having a component radial to the pivot axis.

16. A resonant scanning apparatus having a controllable resonant frequency, comprising:

a first body;

a second body coupled to the first body, the first and second bodies being sized and configured for relative motion at a first resonant frequency; and

a control member coupled to one of the first and second bodies, the control member being responsive to a control signal to produce a damping force on the first or second body, wherein the first and second bodies are responsive to the damping force to move at a second resonant frequency different from the first resonant frequency.

17. The resonant scanning apparatus of claim 16 wherein the second body and the control member are integrally formed from a common material.

18. The resonant scanning apparatus of claim 16 further comprising a torsional arm extending between the first and second bodies.

19. The resonant scanning apparatus of claim 16 further comprising a motion sensor coupled to detect relative motion of the first and second bodies, the motion sensor being operative to produce the control signal in response to the detected relative motion.

20. A method of controlling a scanning motion of a MEMs device, comprising the steps of:

activating the MEMs device for periodic motion of a portion of the MEMs device relative to a reference point, the portion having a center of mass offset from the reference point by a selected distance;

monitoring the periodic motion of the MEMs device;

responsive to the monitored periodic motion of the MEMs device, identifying a deviation of the periodic motion from a desired periodic motion;

generating an error signal in response to the identified deviation; and

responsive to the error signal, changing the selected distance.

21. The method of claim 20 wherein the step of activating the MEMs device for periodic motion of a portion of the MEMs device includes applying an electrical driving signal to the MEMs device.

22. The method of claim 20 wherein the step of changing the selected distance includes deforming the portion of the MEMs device.

23. The method of claim 20 wherein the MEMs device includes a torsional member that supports the portion of the MEMs device and wherein the step of monitoring the periodic motion of the MEMs device includes monitoring torsional stress in the torsional member.

24. The method of claim 20 wherein the step of monitoring the periodic motion of the MEMs device includes optically detecting movement or position of the portion.

25. The method of claim 20 further comprising the steps of:

receiving an input scanning signal; and

determining from the received input scanning signal the desired periodic motion.

26. A method of scanning a light beam in response to a synchronization signal, comprising the steps of:

receiving the synchronization signal having a synchronization frequency;

activating a resonant MEMs device for periodic movement at a resonant frequency;

detecting the resonant frequency of the MEMs device;

synchronizing the MEMs device to the synchronization signal by varying the resonant frequency of the MEMs device; and

scanning the light beam with the resonant MEMs device at the varied resonant frequency.

27. The method of claim 26 wherein the step of detecting the resonant frequency of the MEMs device includes monitoring variation in selected electrical properties of the MEMs device.

28. The method of claim 26 wherein the periodic movement of the MEMs device is about a pivot axis and wherein the step of varying the resonant frequency of the MEMs device includes varying the moment of inertia of the MEMs device relative to the pivot axis.

29. The method of claim 28 wherein varying the moment of inertia of the MEMs device relative to the pivot axis includes deforming a portion of the MEMs device.

30. The method of claim 29 wherein the MEMs device includes a flexible arm and wherein deforming in portion of the MEMs device includes bending the flexible arm.

31. The method of claim 26 wherein the step of scanning the light beam with the resonant MEMs device includes:

directing the beam of light at a moving portion of the MEMs device; and reflecting the beam of light with the moving portion.

32. The method of claim 26 wherein the step of detecting the resonant frequency of the MEMs device and the step of synchronizing the MEMs device to the synchronization signal by varying the resonant frequency of the MEMs device are substantially simultaneous.

33. A MEMs device having an electrically controllable resonant frequency, comprising an oscillatory body configured for periodic movement relative to a reference point, the oscillatory body including a primary portion and a secondary portion that together define a center of mass of the oscillatory body that follows a movement path relative to the reference point, wherein the secondary portion is responsive to an input electrical signal to move relative to the primary portion, and wherein movement of the secondary portion relative to the primary portion varies the movement path of the center of mass.

34. The MEMs device of claim 33 further comprising a flexible link interposed between the primary portion and secondary portion.

35. The MEMs device of claim 33 further comprising a first capacitive plate carried by the primary portion and a second capacitive plate carried by the secondary portion, the first and second capacitive plates being oriented to apply a

force between the primary and secondary portions in response to an applied voltage.